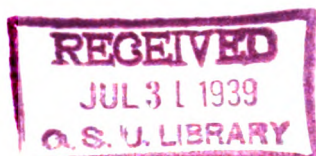


**UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY**

**BUREAU OF MINES
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SOME SIGNALING SYSTEMS IN METAL-MINE SHAFTS



BY

McHENRY MOSIER AND E. J. GLEIM

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME SIGNALING SYSTEMS IN METAL MINE SHAFTS^{1/}

By McHenry Mosier^{2/} and E. J. Gleim^{3/}

INTRODUCTION

This paper describes some mechanical and electrical signal systems in common use in metal-mine shafts, together with several distinctive systems that indicate or control the origin of the signal. The latter systems remove the hazard of the movement of the cage from one level in response to signals from another.

Previous publications of the Bureau of Mines have covered several meritorious installations. One of the best signal systems for deep shafts is at the Homestake mine^{4/}. A successful installation of an induction system in the Lake Superior mining region permits signaling as well as telephoning from cages at rest or in motion^{5/}. El Potosi mine uses a variation of the three-wire electric system^{6/}. A mine in Utah has developed a system of the double trolley-wire type, in which the cage attendant may signal from a moving cage^{7/}. At present no system of the mine-shaft signaling employing radio is available.

Large mines frequently install an electric signal system for regular service and a mechanical system for use in emergencies arising from the failure of the electrical system, from shaft repairs, or from shaft inspection. Many small mines and prospects that have shallow shafts rely entirely upon a mechanical system, the principal features of which are (1) a pull-cord or line in the shaft, (2) a bell crank at the collar of the shaft (see fig. 1), and

- 1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7083."
- 2/ Senior mining engineer, Metal Mining Research Section, Mining Division, Bureau of Mines, U. S. Department of the Interior.
- 3/ Electrical engineer, Pittsburgh Experiment Station, Bureau of Mines, Pittsburgh, Pa.
- 4/ Wiggert, John F., Electric Signal System, Ross Shaft, Homestake Mining Co.: Bureau of Mines Inf. Circ. 6979, 1937, 7 pp.
- 5/ Stewart, L. D., and Potter, E. V., Jr., A New Signaling Device for Shaft Mines with Comments and Suggested Modifications: Bureau of Mines Inf. Circ. 6487, 1931, 10 pp.
- 6/ Walker, Harlan A., Mining Methods and Costs at El Potosi Mine, El Potosi Mining Co., Chihuahua, Mex.: Bureau of Mines Inf. Circ. 6804, 1934, 38 pp.
- 7/ Parker, D. J., and Manning, R. I. C., Signaling from Cages at Rest or in Motion: Bureau of Mines Inf. Circ. 6161, 1929, 7 pp.

(3) a wire on surface connecting the bell crank to a standard spring-trip gong in the engine room.

The bell line down the shaft usually is 1/4 inch in diameter. Galvanized steel sash cord or bronze multiple-strand wire with woven cover makes a serviceable line. Buttons or handles may be fastened to it at regular shaft stations. A spring attached to the bell crank will counterbalance the bell line in the shaft and facilitate its movement. Signaling by this device is slow but in shallow shafts usually is positive. The bell line is accessible not only at shaft stations but also at any point in the shaft between stations.

Individual Installations

At one mine in Arizona a three-wire electric signal system functioned in two hoisting compartments from 12 shaft stations (see fig. 2). Alternating current at 110 volts operated single-stroke bells in the hoist room. In addition to an auxiliary mechanical signal system, a special telephone system not connected to the city telephone exchange was installed for shaft use. Telephones were placed at each shaft station and in the hoist room. One ring on the telephone called the cage attendant, while two rings called the hoistman.

A mine in Arizona used an electric system invented and patented by Joseph J. Luchessa of Miami, Ariz. This system employed a method for signaling to the hoistman controlling the operation of a mine hoist, wherein only signals initiated by the cage or skip attendant were transmitted. The main object of the invention was to remove the hazard of the movement of the cage from any level in response to signals from some other level.

The signaling circuit (see fig. 3) comprised (1) a gong connected by wire to an insulated brass ring on the dial of the indicator at the hoist, (2) a series of contact members of insulated sections of arcs of a concentric brass ring having a diameter slightly larger than the first ring, (3) wires connecting these contact members to switches at the respective shaft stations (4) and a return connection from the switches to the source of current connected to the gong.

The movement of a circuit-closing member integral with the pointer on the dial of the indicator was synchronized with the movement of the cage in such manner as to connect the gong with the switch at each successive station as the cage passed or was adjacent to it.

The call bells operated from the several shaft stations for the cage attendant were on a separate and independent system from the signal system just described.

A modification of this system on a 220-volt, alternating-current circuit was used at another western property. A metal brush was fastened to the underside of the pointer on each cage indicator at the hoist in contact with a brass ring attached to the face of the dial of the cage indicator at its perimeter (see fig. 4). A smaller concentric ring carried 10 brass segments

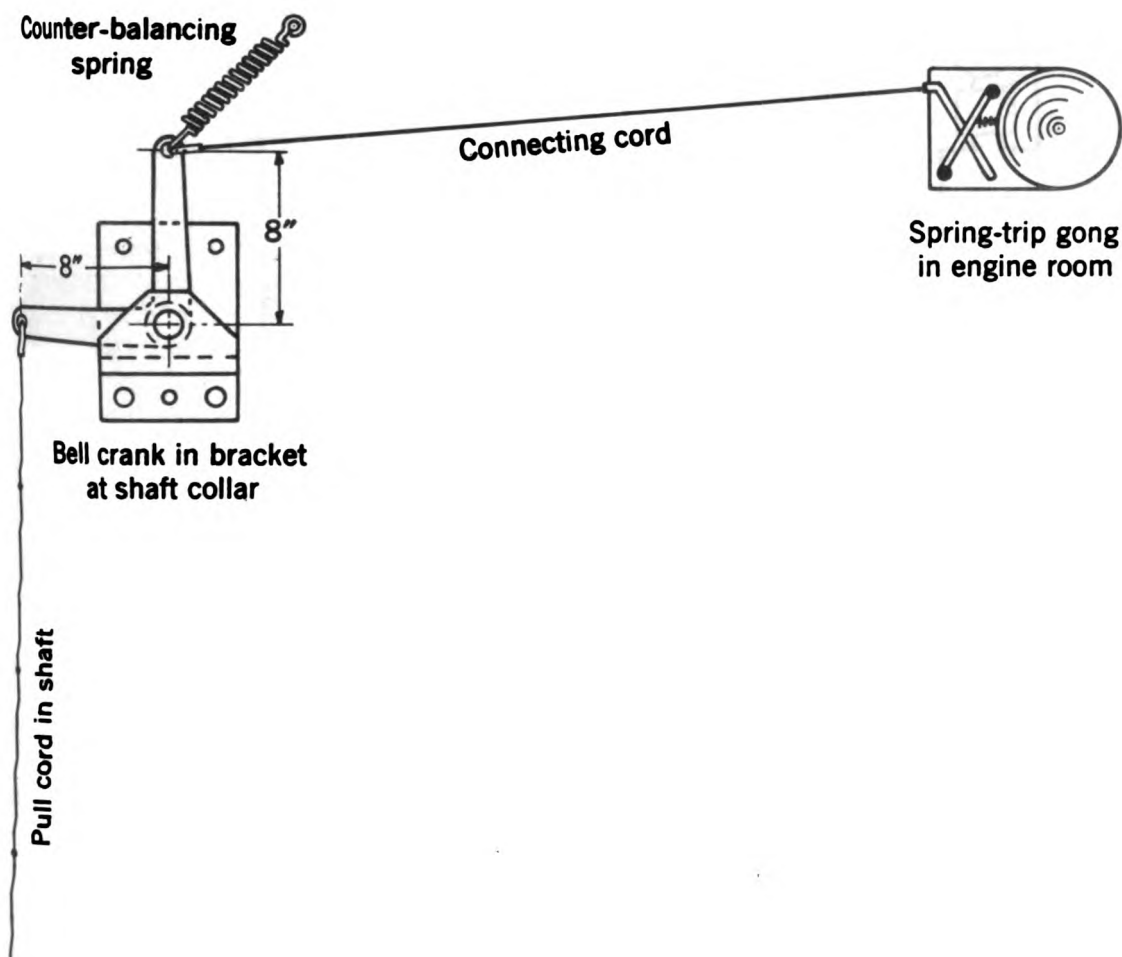


Figure 1.—Mechanical signal system.

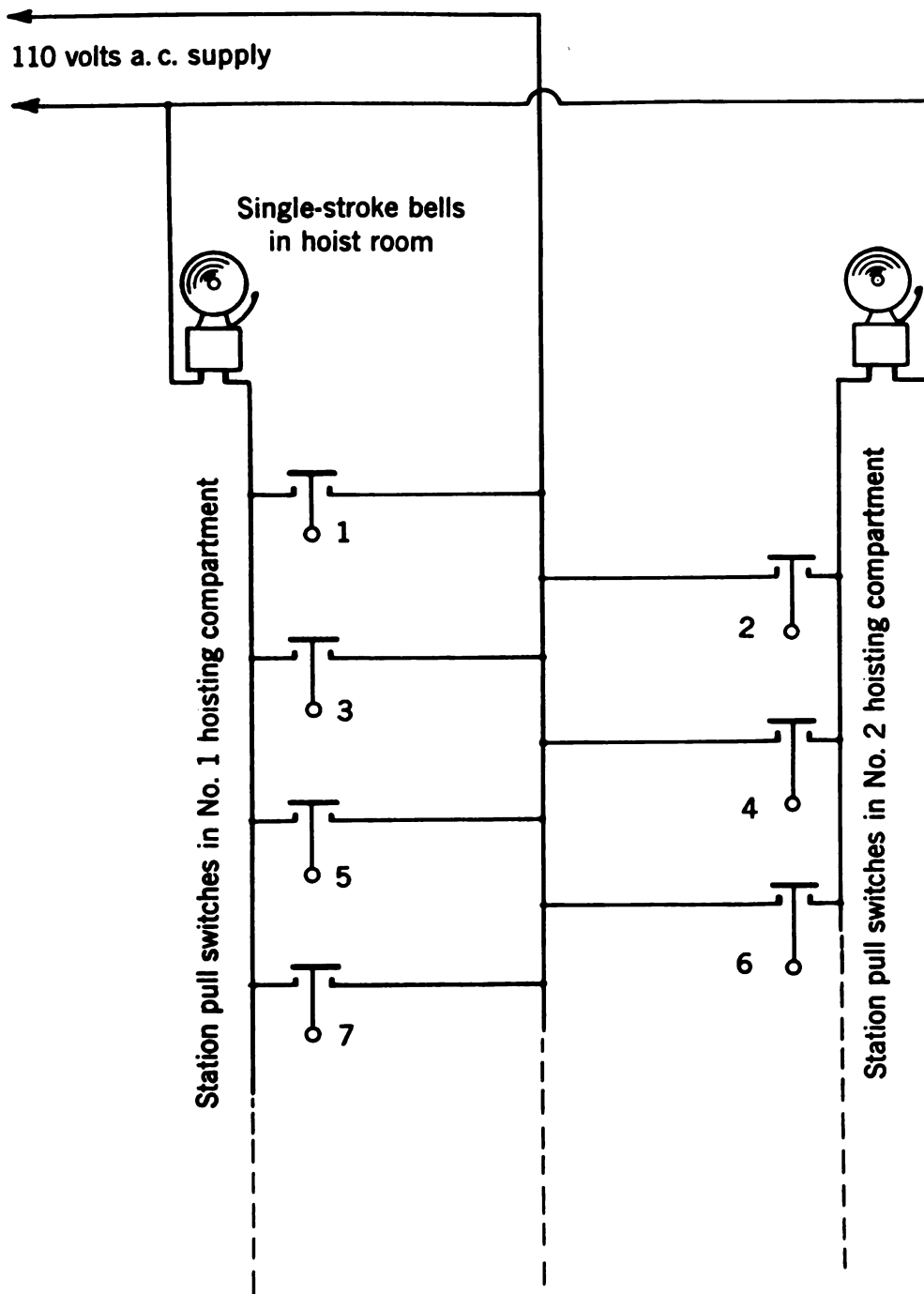


Figure 2.—Three-wire signal system.

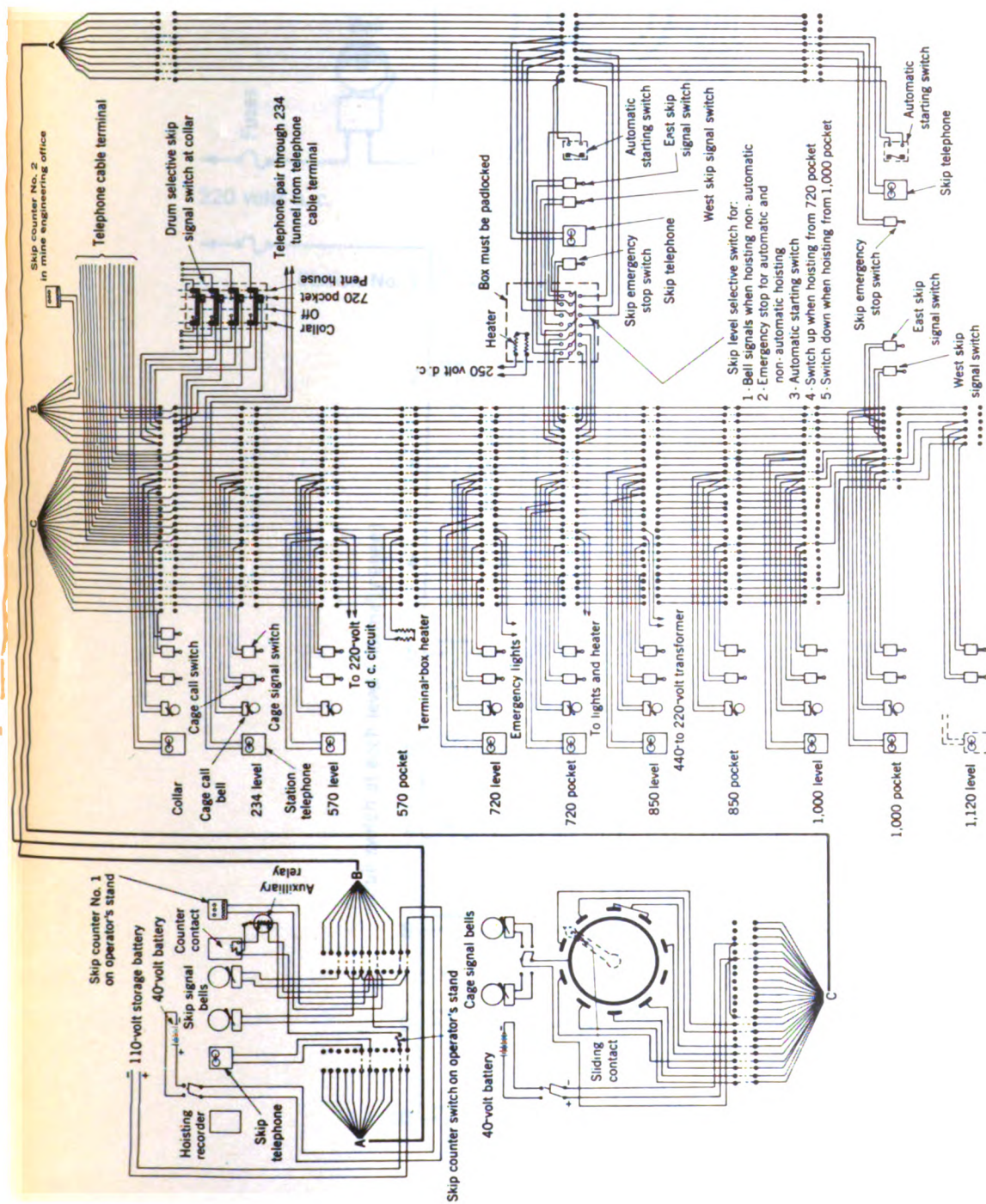


Figure 3.—Wiring diagram for Luchessa signal system.

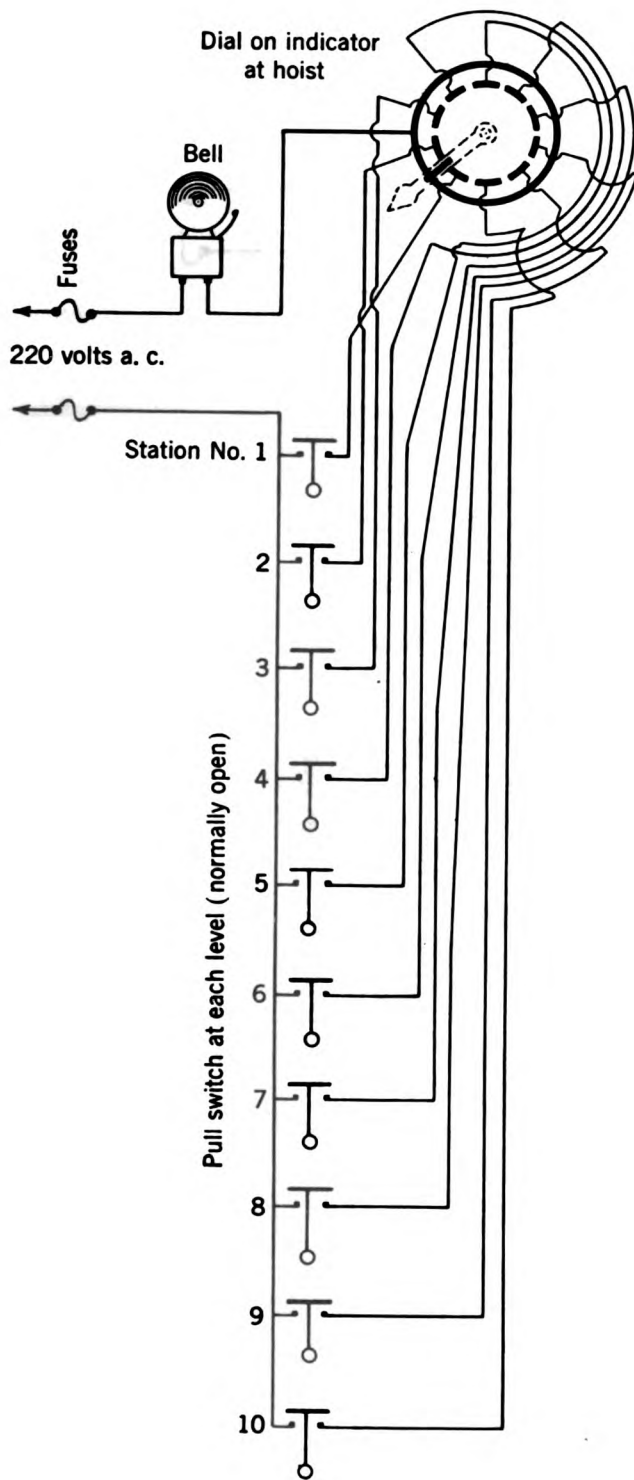


Figure 4.—Wiring diagram of circuit for signaling hoist engineer.

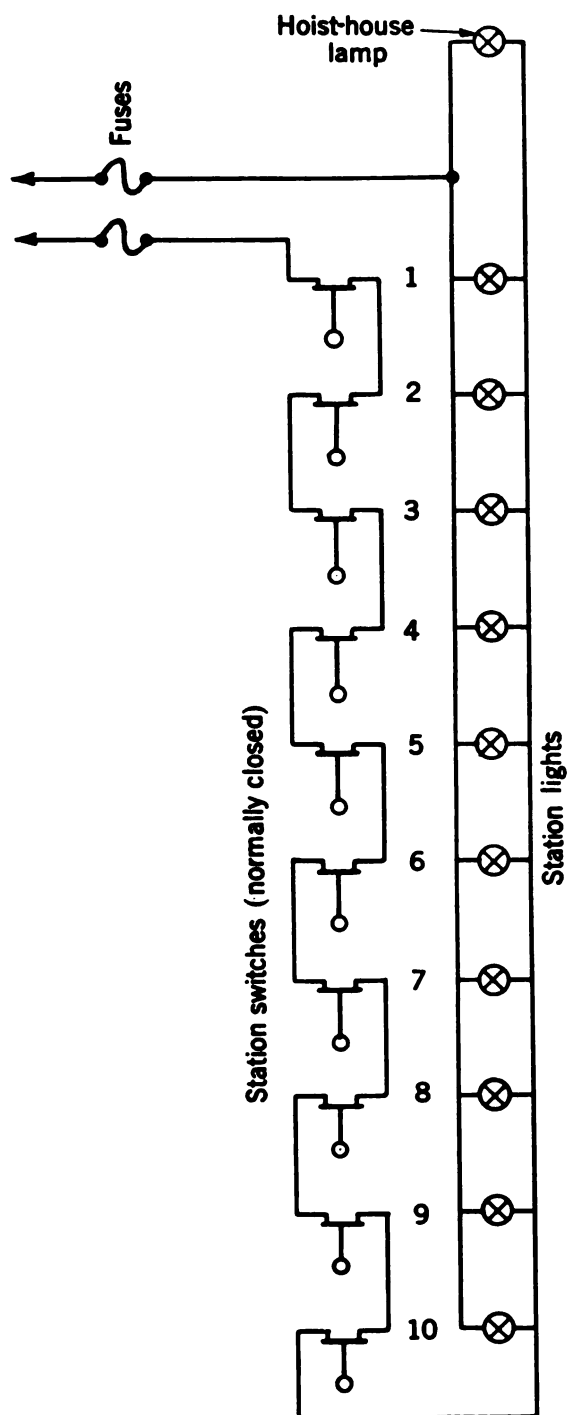


**Figure 5.—Wiring diagram of circuit
for signaling cage attendant.**

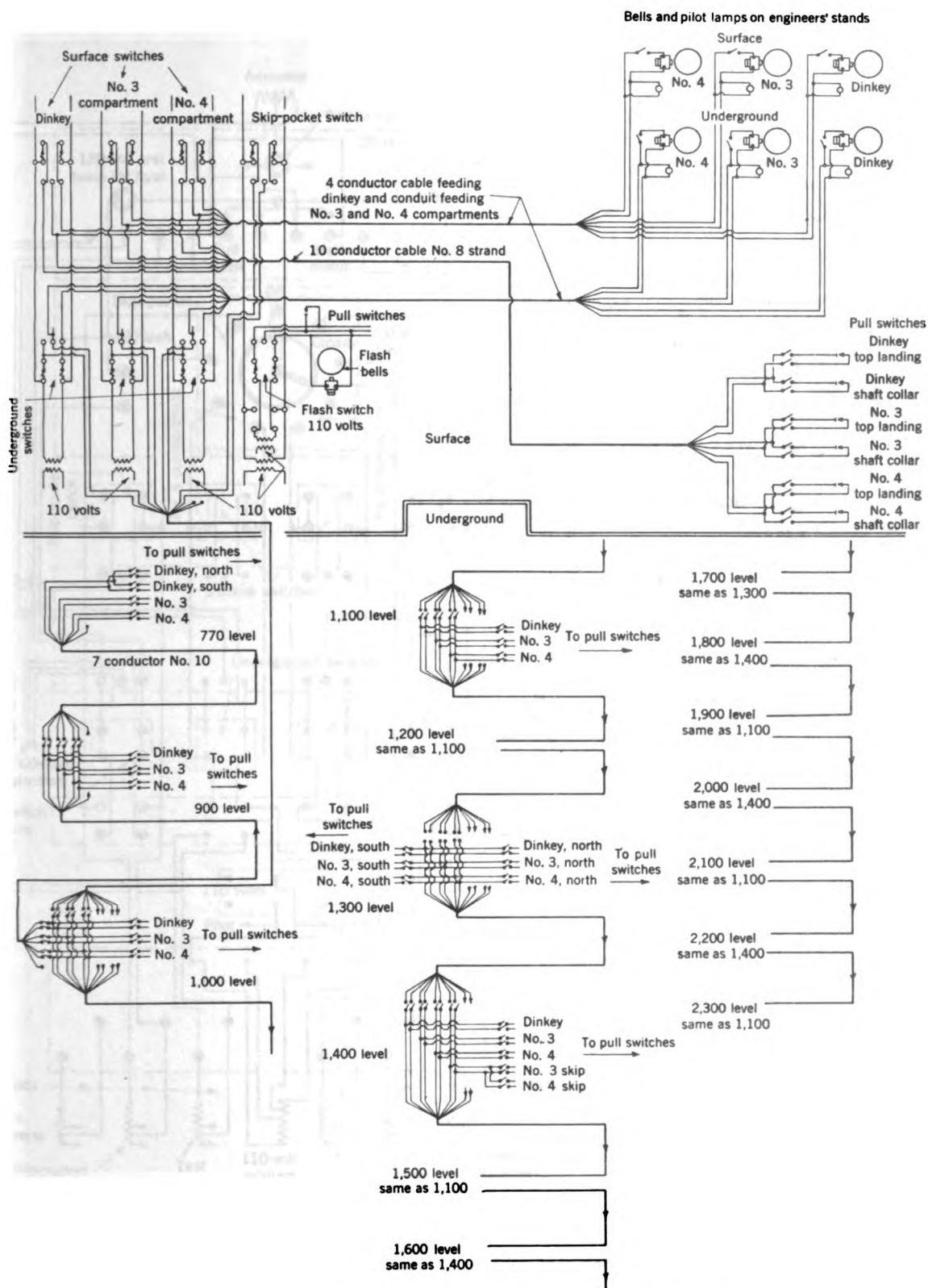


Figure 6.—Details of wiring diagram for hoisting signal bells.

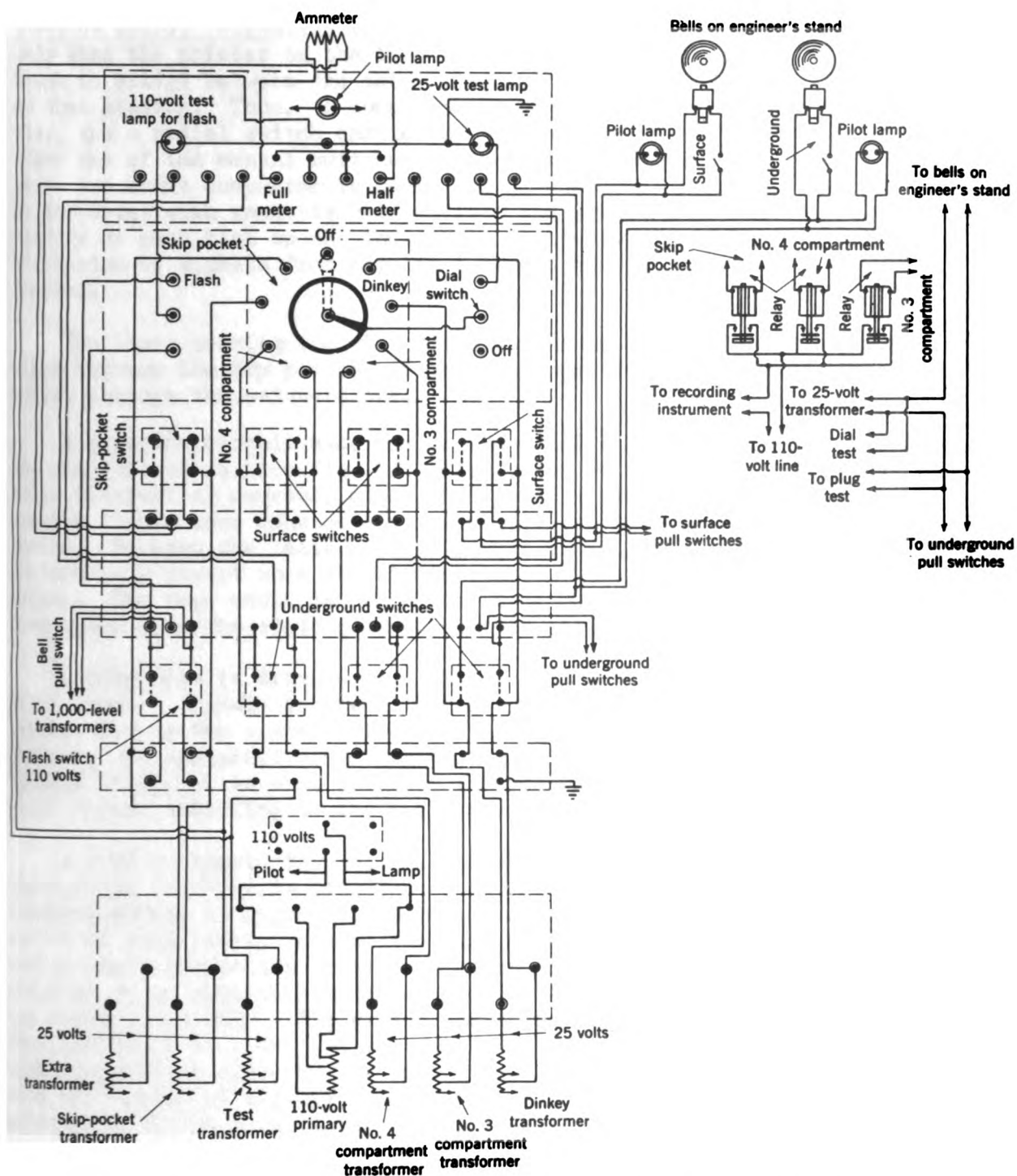


Figure 7.—Details of wiring diagram for surface terminal of hoisting signals.

corresponding to the shaft stations. Both the outer brass ring and the inner brass segments were insulated from each other by mounting them on asbestos board. Signaling from any station in the shaft could be accomplished only when the pointer on the cage indicator at the hoist moved the metal brush to bridge between the outer ring and the brass segment corresponding to that station. Thus, to complete the circuit, two switches were required, viz., one a radial switch carried by the pointer on the indicator dial, the other one of the manual switches at the shaft stations. The dual circuit to serve two shaft compartments consisted of one common wire for the two dials at the hoist with separate returns from the switches at each level to the conductors at each dial on the indicators at the hoist. This prevented the initiation of signals from any level except that at which the cage was located.

The lines serving the 10 shaft stations were No. 12 rubber-covered wires through the dry portion of the shaft and No. 12 conductors in lead cables through the wet portions.

A separate circuit made use of the shaft station lights for signaling the cage attendant (see fig. 5). The supply at this installation was 220 volts alternating current, although it may be any suitable voltage. The station lights were connected in parallel, but the station switches were in series. Because the latter normally were closed, the station lights burned continuously except when the station switch was pulled and the circuit broken. The cage could be called to any level by blinking the lights to correspond with the state code of station signals.

A deep mine in Arizona used an electric system with both bells and pilot lamps. Signals to the hoistman were given by a pull switch at each level. The system was energized at the surface with 110 volts alternating current. In the shaft or underground circuit, transformers reduced the voltage to 25, or to that required for the resistance of the signal circuit, which varied according to the depth of the shaft.

A wiring diagram for this installation in a 2,300-foot shaft with 16 underground stations is illustrated in figure 6. Details of the surface terminal appear in figure 7. A long sash cord, which hung on the pull switch at each level, enabled the cage attendant to signal between levels during shaft inspection or other emergencies. In addition, a wire rope attached to an electric switch at the collar of the shaft was installed in one compartment only. The switch was in an electric circuit that extended from the shaft to a bell at the hoist. By this means, in an emergency, signals could be given by the cage attendant to the hoistman. In conjunction with the system of signals to the hoistman, a call-bell system for cage attendants with a gong on each level operated on a 3-wire circuit in parallel using 110 volts alternating current. Any one desiring the cage rang the appropriate station signal (standard State code) for the cage attendant. This system functioned only when the cage attendant was at a shaft station, because he could not hear the signal when he was traveling between stations.

At a gold mine in Colorado a main supply raise had an electrically operated signal system whereby the cage attendant could signal the hoistman audibly and visibly from any station for the movement of the cage by means of an 8-inch gong and 50-watt lamps. At the same time an annunciator panel indicated the particular station from which the signal originated. The signal on the annunciator was transient, in that the lamp did not remain lighted after the signal was given (see fig. 8). This system provided an excellent safeguard against moving the cage on a signal that was not given by the cage attendant.

Two common lines (No. 10 R.C.) extended the full length of the raise from the hoist to the highest station. The portion from the hoist to station 4 was a lead-sheathed cable. In addition, there was one separate single wire from each of the five stations to the hoist station (No. 12 R.C.). The alternating current required for the system was 220-volt, 60-cycle, single-phase. When a signal switch was closed, current flowed through the corresponding 50-watt lamp on the annunciator panel in series with the gong in the hoist room. The rating for the lamp and the gong was 110 volts each. Adjacent to the signal switch at each station was a weather-proof socket for fuse or test lamp. By opening and closing the main signal power switch, which was normally held closed by a spring, the hoisting engineer could signal to the cage attendant by flashing the station lights.

A similar system, but with only three stations, is also used at an auxiliary supply raise in this same mine.

A copper mine in Arizona that had 19 levels between depths of 500 and 3,000 feet used an electric system with signals for the cage attendant on 32 volts direct current from a motor generator set and with signals for the hoistman on 110 volts alternating current.

In the system for calling the cage, one pair of wires connected each shaft station with an annunciator in the hoist room. The wires were rubber-covered and were enclosed in a regular telephone-type lead-covered cable. Signals were initiated by a pushbutton on each station and were indicated on the annunciator by a pointer. The hoistman repeated the signals by means of a pushbutton on a separate circuit supplied with 110 volts alternating current. This simultaneously flashed a lamp at each shaft station. These lamps were connected in parallel.

The signals to the hoistman for the movement of the cage or skip were on a 2-wire, 110-volt, alternating-current circuit with a pull switch (see fig. 9) at each station, which rang a gong in the hoist room. The switches were inside of the shaft-station gates within reach of the cage attendant while standing in the cage.

DISCUSSION

Electric signal systems are standard equipment at most metal mines. An essential adjunct to any system for signaling the hoistman is a means for calling the cage to any desired point in the shaft. It is obvious that for

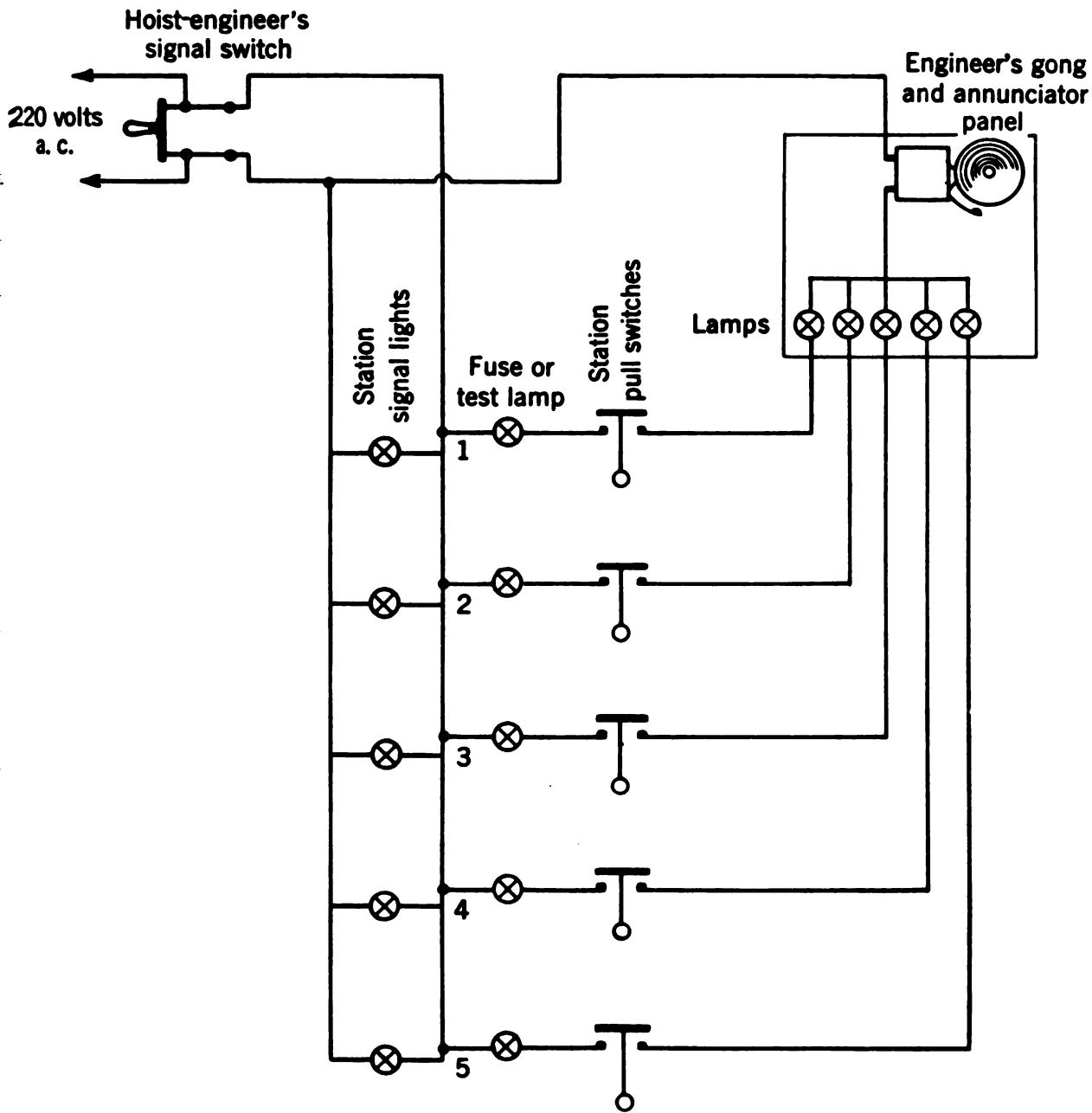


Figure 8.—Wiring diagram for signal system with annunciator.

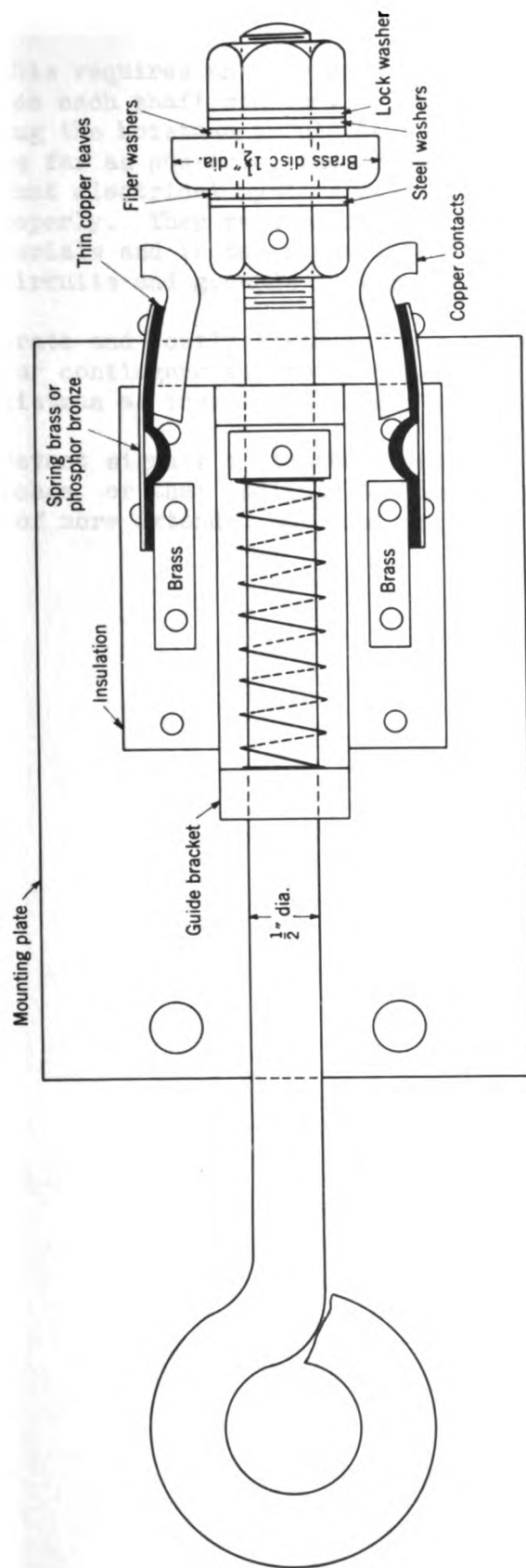


Figure 9.— Pull switch for shaft signals.

electrical systems this requires an independent circuit with manual switches conveniently placed on each shaft station. On the other hand, the manual switches for signaling the hoistman should be concealed from any one on the shaft station and, as far as possible, should be inaccessible from the shaft station. In order that electrical systems may give dependable service, they must be installed properly. They require special precautions in the selection of suitable materials and in their installation to prevent moisture from causing short circuits and grounds in the circuits.

Except at elaborate and costly installations where enough safeguards have been provided for contingencies, most large mines provide a dual system of signals to the hoistman as insurance for continuous operation.

Systems that prevent signals to the hoistman from originating at any point except at the cage, or that indicate to him the point of origin of signals, are worthy of more extended application at both large and small operations.